Adapting for Uncertainty: A Scenario Analysis of Technology Energy Futures

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Technology-Based Thinking as a Key to Future Economic and Environmental Opportunities

- In the words of Kenneth Boulding: "Images of the future are the keys to choice-oriented behavior."
- Exploring a wide range of alternative scenarios (including technology paths) can help us better understand the ordinary business of making better decisions about the environment and the economy.
- This idea was explored in a new EPA-Argonne National Lab assessment, "Engines of Growth: Energy Challenges, Opportunities, and Uncertainties in the 21st Century" by Donald A. Hanson, Irving Mintzer, John A. "Skip" Laitner, and J. Amber Leonard, Argonne National Lab, January 2004 (http://amiga.dis.anl.gov).

A Wide Range of Scenarios Can Represent a Variety of Plausible "Base Case" Scenarios

Beyond a standard reference case scenario, the likelihood of these additional scenario outcomes cannot be disproved:

*****The US Confronts Big Problems Ahead

Severe political disruption in the Middle East. Climate change becomes severe. Destroyed ecosystems are major concern.

Cheap Energy Reigns in the Market

Abundant energy supplies keep energy prices down. Environmental problems thought to be relatively unaffected by rising energy use.

Technology Investment Drives the Market

Technology investment stimulates innovation and efficiency gains, but for other than environmental reasons.

Hence, We Might Explore Interactions and Outcomes from 4 Basic Scenarios

- The AEO 2002 Reference Case extended through the year 2050; and the three alternative storylines previously suggested:
 - Cheap Energy Reigns Supreme;
 - Big Problems Ahead; and
 - Technology Drives the Market.
- To test the idea of the robustness of each scenario, it is further assumed that each alternative base case or storyline is confronted by an unexpected challenge with a need for immediate response post-2010.

The Really Big Insight

- While the equivalent AEO Reference Case supports a 2.7 percent annual growth rate in GDP over the forecast period 2000 through 2050.
- The assumption of *Cheap Energy Reigns* and *Technology Drives the Market* will both drive a slightly higher growth rate of 2.8 percent (compared to a 2.4 percent growth with *Big Problems Ahead*).
- The *Technology Investment* strategy, however, will better position the economy and the environment to respond and adapt to unexpected future challenges.

About the AMIGA Modeling System Used to Assess the Different Scenarios

(http://amiga.dis.anl.gov)

AMIGA Is a Comprehensive Model that Integrates Energy Markets, Technologies, and Policies

- The AMIGA Modeling System is a general equilibrium model developed and supported by the Argonne National Laboratory that:
 - Examines the impact of changes in more than 200 individual sectors and energy markets of the US economy (in terms of both dollars and physical units).
 - Programmed in the structured C language, AMIGA integrates a detailed energy market specification within a structural economic model.
 - Calculates both prices and detailed macroeconomic variables as consumption, investment, government spending, sector employment and output, and GDP.
 - Provides equilibrium paths from the present through the year 2050, with the capability of extending the time horizon out to 2100.
 - Handles a rich set of energy supply technologies (including renewables, sequestration, and hydrogen infrastructure) and detailed end-use efficiency technologies.
 - Includes the ability to reflect cap and trade, early allowances, and the banking of the full basket of greenhouse gas emissions as well as electric sector air emissions.



AMIGA Modeling System, Version 4.0

- Version 1.0 was a strictly energy-economic framework developed for DOE/EERE Office of Transportation Technologies (OTT) with a 2020 time horizon and used for preparing the OTT R&D Report to Congress.
- Version 2.0 included carbon emissions and tracked the NEMS Annual Energy Outlook and was used for Clean Energy Future (CEF) analysis.
- Version 3.0 incorporated the Argonne Unit Planning and Compliance model and SO₂, NO_x, and Hg emissions and trading and was used for the Jeffords-Lieberman analysis and EMF-19 scenarios.
- Version 3.1 increased representation of the transportation sector with a 2050 time horizon and was used for Pew Climate Center and Keystone scenario analysis.
- Version 4.0 adds the other (Non-CO₂) greenhouse gases and 22 total world regions with a time horizon out to 2100.

Further Scenario Descriptions

The Official Energy Future

- Based on the AEO 2002 projection through 2020 with a continuation of current market trends, technology expectations, and policies through the year 2050.
- Emphasis on expanding supply of oil and gas, promoting new nuclear technologies.
- Leads to reduction in carbon intensity of the economy but large increase in CO₂ emissions.

Cheap Energy Reigns Supreme

- Oil and gas are cheap and abundant
- OPEC fails to control supply and price
- Technology advances open new fields in frontier areas and from non-conventional sources
- Low prices discourage efficiency and alternatives
- Canada and Mexico become primary suppliers for US markets

Technology Drives the Market

- Parallel forces converge, driving fundamental market transformation
- Forces include:
 - State policies and regulatory standards
 - Increased public and private R&D
 - Larger private investment in new technologies
 - Consumer preferences for those technologies perceived to be convenient, safe, reliable, and clean

Big Problems Ahead

- A chaotic world, disrupted by unexpected events, domestically and internationally
- Surge of Islamic fundamentalism in the Persian Gulf leads to fall of House of Al-Saud
- Successful terrorist attack on US nuclear plant thwarts resurgence of nuclear industry
- Severe ice storm takes down NE transmission grid
- Uncertainty slows investment, GDP growth

All Scenarios Share Common Elements

- US GDP grows significantly
- Natural gas use increases
- Electricity demand grows rapidly
- Distributed generation captures increasing share of electricity market
- CO₂ emissions increase by about 50% while criteria pollutants decrease 80% or more over the period 2000 through 2050

Challenge and Response: Testing in the "Wind Tunnel"

- Assumes a critical challenge or surprise and analyzes the response of key actors and institutions in the scenarios.
- For the EPA-Argonne study, the critical challenge is an assumption of rapid climate change around 2010 with a need for an immediate response.
- Response in each scenario is to identify and implement policies that can dramatically reduce US carbon emissions while sustaining economic growth.

Principal Elements of the Response in Each Scenario

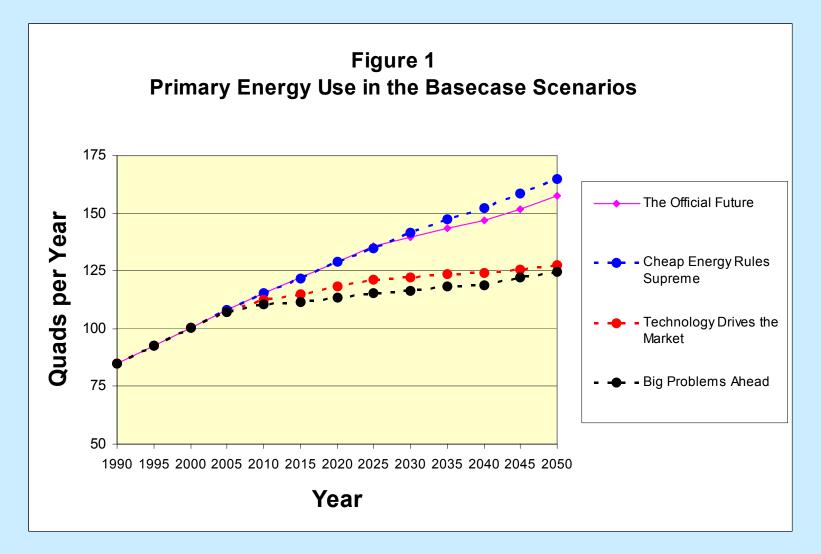
- Carbon cap-and-trade program for large stationary emitters
- Tradable energy performance standards for manufactured products
- Efficiency trading programs for new vehicles in the transport sector and investment tax credits for high efficiency vehicles
- Tax credits for hydrogen production
- Information and training programs

Response to the Challenge

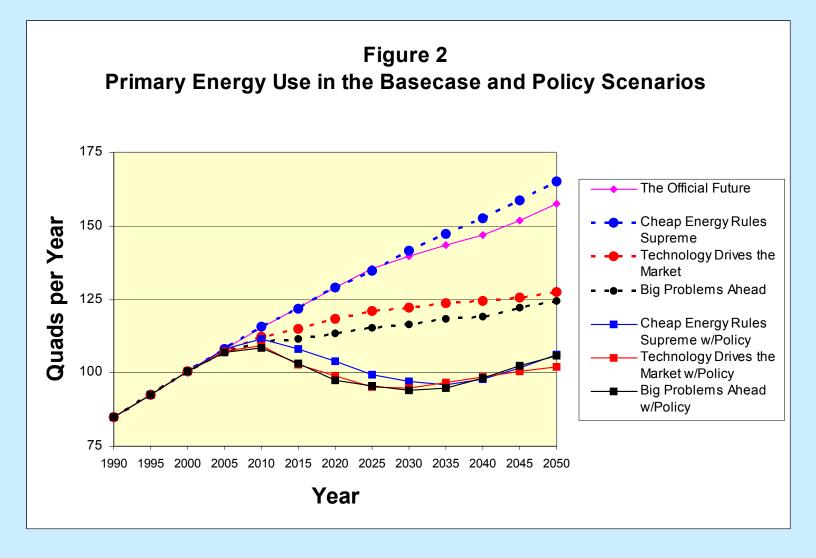
- In three scenarios a challenge is applied, response causes carbon emissions to fall by ~35% by 2035 and ~50% by 2050 from 2000 levels.
- No significant negative impacts on economic development, as measured by GDP growth.
- Crude oil imports decline by ~75% by 2050, relative to the 2000 level in all Challenge and Response cases.
- Substantial reduction in oil import dependence and vulnerability of energy facilities.

Scenario Results

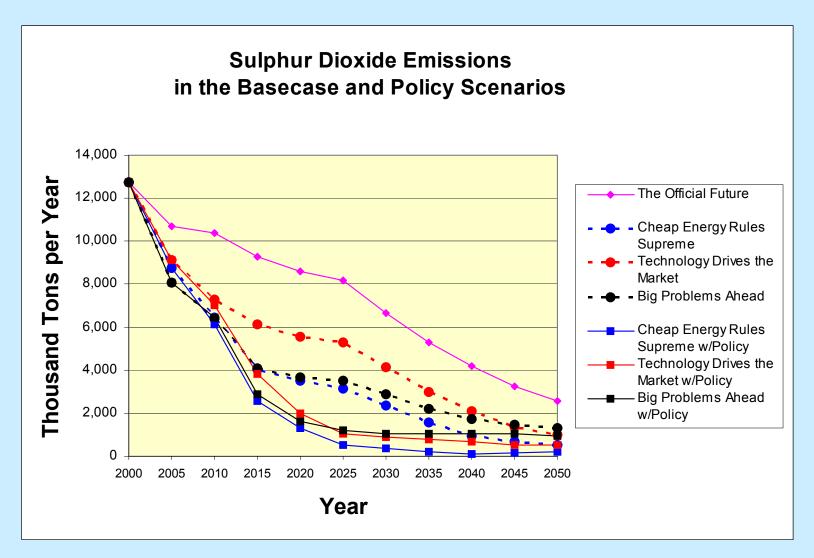
US Energy Demand Up 25-65% in the Reference and Base Case Scenarios



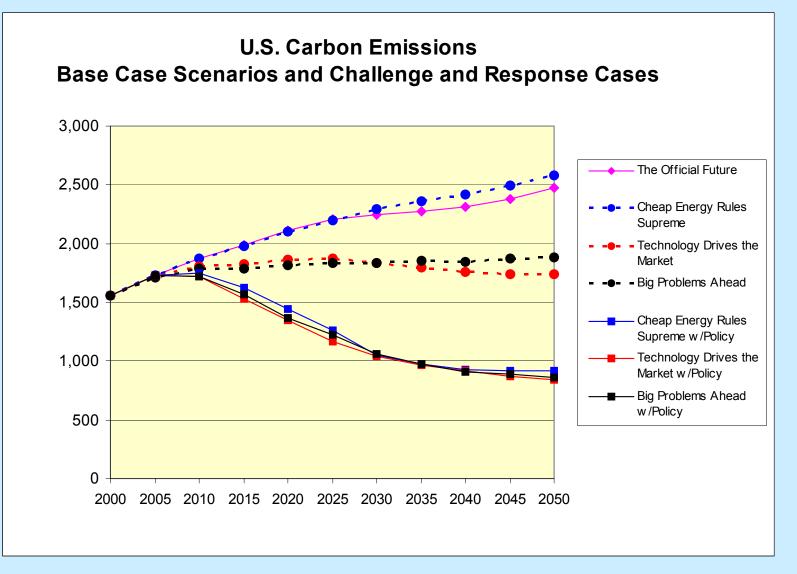
US Energy Demand Grows Less than 10% in the Challenge and Response Scenarios



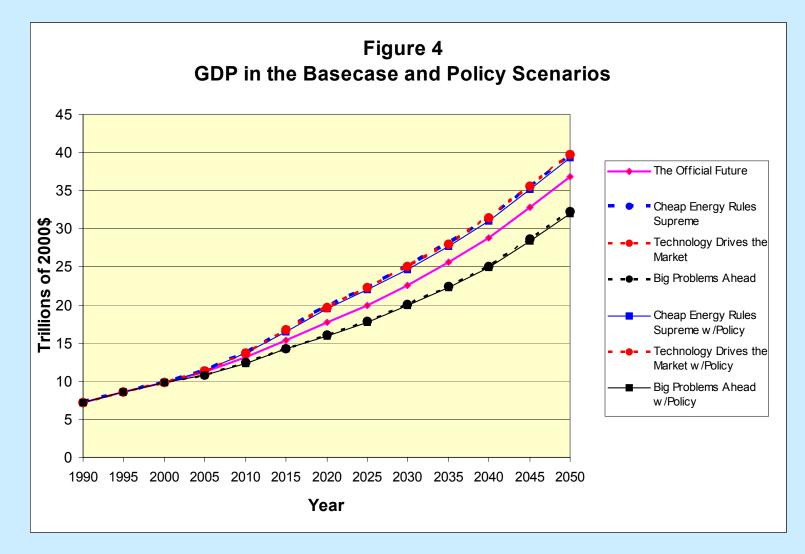
Electricity Air Emissions Down in All Scenarios Although Significantly More in Policy Cases



Carbon Emissions Up in Base Cases And Down Significantly in Policy Cases



Carefully Targeted Policies to Accelerate Stock Turnover and Low-emission Technologies Have No Significant GDP Impact in the Challenge and Response Scenarios



Conclusions and Implications (1)

- Scenario analysis can be an important and useful tool for exploring energy futures.
- The range of feasible energy futures is broad, but energy use increases in all scenarios with strong economic growth.
- Policies to encourage capital stock turnover and accelerate commercialization of high-efficiency, low-emission technologies can significantly reduce growth in US primary energy demand and CO₂ emissions.

Conclusions and Implications (2)

- Low energy prices can lead to high economic growth; but so can a smart investment path that emphasizes energy efficiency and advanced technologies.
- Today's public and private choices, along with external events, will affect the cost of responding to unexpected future outcomes or surprises.
- Hence, the near-term task is to identify the mix of technology investments that satisfy multiple social goals (national security, environmental quality, equity, and a robust economy) — given conditions of deep uncertainty.

Important Caveats

- The scenario results should be seen only as reasonable storylines that can inform decision makers about potential outcomes and consequences rather than recommendations for any given set of policies.
- The GDP pathways are based on a variety of technology assumptions and external events, but they do not reflect such issues as changes in consumer confidence or preferences, the "Fed Function," or unexpected market or behavioral shifts.

For more information on the material referenced in this summary, contact:

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The preliminary findings contained in this conference presentation are believed to rely on credible and accurate sources of information. Any errors in the analysis are solely the responsibility of the analytical team completing the assessment. The results of the energy scenarios described herein should not be construed as reflecting the official views of the U.S. Environmental Protection Agency, Argonne National Laboratory, or the U.S. Government.